REMARKS

This application has been carefully reviewed in light of the Office Action dated June 7, 2002. Claims 1, 13, 14, 36, 43, and 64 have been amended. A marked-up version of these claims, showing changes made, is attached hereto as Appendix A. Claims 1-25, 36-46, and 64-70 are pending in this application. Applicant reserves the right to pursue the original claims and other claims in this application and in other applications. No new matter has been introduced. Applicant respectfully requests reconsideration of the above-referenced application in light of the amendments and following remarks.

A "Request for Approval of Proposed Drawing Amendments" is being filed concurrently herewith. In the request, Figures 1 and 2 (described in the Background section of Applicant's specification) have been labeled as "Prior Art."

In the present Amendment, claim 1 has been amended to recite in pertinent part that the "flow rate ratio of said at least one fluorocarbon to said ammonia is from about 2:1 to about 40:1." Support for this recitation is found in Applicant's specification at page 9, lines 1-5.

Claims 13 and 14 have been amended to recite in pertinent part "forming sidewall spacers along the sides of gate stack structures, wherein said etching is performed such that the sidewall spacers of said gate stack structures are not etched, wherein said sidewall spacers define at least in part said opening formed in said insulative layer." Support for this recitation is found in Applicant's figures 1-3.

Claim 36 has been amended to recite in pertinent part that the "flow rate ratio of said at least one fluorocarbon to said ammonia is from about 2:1 to about 40:1." Support for this recitation is found in Applicant's specification at page 9, lines 1-5.

Claim 43 has been amended to maintain proper antecedent basis. In particular, claim 43 recites in pertinent part that "said opening is formed between said sidewall spacers on said pair of adjacent gate stacks."

Claim 64 has been amended to recite in pertinent part "a method of forming a conductive plug between adjacent gate stacks with sidewall spacers and inside a self-aligned contact opening formed in an insulative layer provided over a substrate in a semiconductor device . . . wherein the flow rate ratio of said at least one fluorocarbon to said ammonia is from about 2:1 to about 40:1." Support for this recitation is found in Applicant's specification at page 9, lines 1-5.

Claims 2, 13-14, 36-46, and 64-70 stand rejected under 35 U.S.C. §112, second paragraph, as allegedly being indefinite. In response, claims 13-14, 36, and 64 have been amended to correct any perceived indefiniteness.

At the outset, Applicant notes that Figures 1 and 2 (described in the Background section of Applicant's specification) have been labeled as prior art. Figures 1 and 2 illustrate that the formation of sidewall spacers, gate stacks, adjacent gate stacks, and self-aligned contact openings are well-known in the art.

Applicant respectfully submits in regard to claim 2 that self-aligned contact openings are well-known in the art (See Figs. 1-2 and pages 2-3, Applicant's specification). See, for example, the description of the formation of "a self-aligned contact (SAC) opening" at Applicant's specification page 1, line 1, through page 3, line 9.

Claims 13-14 have been amended to positively recite the formation of sidewall spacers and to emphasize that the claimed method does not etch any portion of the sidewall spacers. Further, as evidence, Applicant's specification provides that sidewall spacers are well-known in the art (See Figs. 1-2 and pages 1-3, Applicant's specification).

Applicant respectfully submits in regard to claim 36 that the formation of adjacent gate stacks with sidewall spacers on the sidewalls of the adjacent gate stacks are well-known in the art (See Figs. 1-2 and pages 2-3, Applicant's specification).

Applicant respectfully submits in regard to claim 37 that self-aligned contact openings are well-known in the art (See Figs. 1-2 and pages 2-3, Applicant's specification).

Applicant has amended claim 43 to establish proper antecedent basis. Specifically, claim 43 now recites that "said opening is formed between said sidewall spacers on said pair of adjacent gate stacks."

Applicant has amended claim 64 for further clarification and proper antecedent basis. Applicant also respectfully submits that the location and formation of a contact opening and insulative layer between adjacent gate stacks is well-known in the art (See Figs. 1-2 and pages 2-3, Applicant's specification).

Accordingly, Applicant respectfully requests that all § 112 rejections be withdrawn.

Claims 1, 3, 8-12, and 15 stand rejected under 35 U.S.C. § 102 as being anticipated by Smolinsky et al. "Reactive Ion Etching of Silicon Oxides with Ammonia and Trifluoromethane, The Role of Nitrogen in the Discharge," J. Electrochem. Soc.: Solid-State Science and Technology, Vol. 129, No. 5, May 1982, pp. 1036-1039 (hereinafter "Smolinsky"). Reconsideration is respectfully requested.

The claimed invention is directed to a method of forming a self-aligned contact opening by etching an insulative layer with a composition consisting essentially of ammonia and at least one fluorocarbon. As a result of utilizing this particular etching composition, an etch-stop, e.g., a polymer layer, is advantageously <u>not</u> formed at the bottom of the self-aligned contact opening (Applicant's Specification, pages 2-3). The structure that results from the claimed invention is preferable over that which results from the prior art methods. That is, as described in Applicant's background section, "a buildup of polymer layer 29 at the bottom of the SAC opening 27 can cause an undesirable phenomenon known as 'etch stop', in which further etching through the insulative layer 21 to the surface of the substrate 12 is prevented by this polymer layer build up 29. In effect, the etch stop polymer 29 formed from the insulative layer can significantly inhibit suitable formation of the contact opening 27." (Applicant's specification, page 3, lines 5-9).

Accordingly, claim 1 has been amended to recite, "a method of forming an opening . . . comprising etching . . . with an etching composition consisting of essentially of ammonia and at least one fluorocarbon so as to form said opening, wherein the flow rate ratio of said at least on fluorocarbon to said ammonia is from about 2:1 to about 40:1." (emphasis added).

Smolinsky fails to teach an "etching composition consisting of at least one fluorocarbon and essentially of ammonia . . . such that the flow rate ratio . . . is from about 2:1 to about 40:1." (emphasis added). In particular, Smolinsky teaches only that "NH_3/CHF_3 plasma proves to be a superior etchant for SiO_2 or P-glass on poly-si." (Smolinsky, page 1038). Smolinsky does not teach a flow rate ratio from about 2:1 to about 40:1 as the claimed invention. Accordingly, Smolinsky does not anticipate the claimed invention.

Claims 3, 8-12, and 15 depend from and incorporate all of the limitations recited in claim 1. For at least the reasons given above, claims 3, 8-12, and 15 are similarly allowable along with claim 1.

Claims 1, 3, and 8-12 stand rejected under 35 U.S.C. § 102 as being anticipated by Levinstein et al. (U.S. Patent No. 4,985,373) ("Levinstein"). Reconsideration is respectfully requested.

Applicant respectfully submits that Levinstein fails to anticipate the present invention. Levinstein is directed to preventing the formation of fissures in insulating layers as a result of two levels of metallization (Col. 2, lines 18-20). In particular, semiconductor MOS devices containing these levels of metallization layers can short-circuit when undesirable cracks are generated in the insulating layer (Col. 1, lines 50-62). The metal in the second metallization layer can migrate down to the first metallization layer as a result of the cracks in the insulating layer (Col. 1, lines 60-62). Thus, Levinstein teaches a method of preventing fissure formation by providing a phosphorus-rich oxide layer 14, a phosphorus-poor layer 15, and forming apertures 21 and 22 within layers 14 and 15 (Col.

4, lines 44-49).

However, Levinstein fails to teach forming an opening, much less a self-aligned contact opening by an "e etching composition consisting of essentially of ammonia and at least one fluorocarbon so as to form said opening, wherein the flow rate ratio of said at least on fluorocarbon to said ammonia is from about 2:1 to about 40:1," as recited by claim 1 (emphasis added). Further, Levinstein is directed to solving a different problem than that addressed by the Applicant's invention; Levinstein is directed to addressing fissures generated within an insulating layer. Levinstein does not address eliminating the formation of an etch-stop in a contact opening. Accordingly, Levinstein does not anticipate the claimed invention.

Claims 3 and 8-12 depend from and incorporate all of the limitations recited in claim 1. For at least the reasons given above, claims 3 and 8-12 are similarly allowable along with claim 1.

Claims 1-25, 36-46, and 64-70 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Park (U.S. Patent No. 6,103,137) in view of Smolinsky. Reconsideration is respectfully requested.

The Applicant respectfully submits that the cited combination of references fails to render obvious the claimed invention. Park discloses a method of plasma etching an oxide layer with three different etching gases. The first gas is a main etch gas, the second gas is used as an angle adjusting gas, and the third gas has a very high C/F ratio (Col. 3, lines 49-56). Whereas, Smolinsky teaches the effect of adding nitrogen or ammonia to only a CHF_3 discharge (Smolinsky, pg. 1036). As discussed previously, Smolinsky teaches that a "NH_3/CHF_3 plasma proves to be a superior etchant for SiO_2 or P-glass on poly-si." (Smolinsky, pg. 1038) (emphasis added).

There is simply no motivation to combine Park with Smolinsky. Smolinsky teaches a two-composition mixture; whereas, Park requires three different gases to etch the

oxide layer. In fact, Park discloses four specific combination sof gases that can only be used in conjunction with Park's invention (See Col. 3, lines 40-46). Park does not suggest that ammonia or any other gas can be substituted in lieu of the gas combinations he specifically discloses, let alone in the particular flow rate ratio as claimed.

Accordingly, the cited references fail to disclose "[a] method of forming an opening . . . comprising etching . . . with an etching composition consisting of essentially of ammonia and at least one fluorocarbon so as to form said opening, wherein the flow rate ratio of said at least on fluorocarbon to said ammonia is from about 2:1 to about 40:1," as claim 1 recites, or "[a] process for forming an opening [by] forming a pair of adjacent gate stacks . . . forming sidewall spacers on sidewalls of said adjacent gate stacks, forming a patterned photoresist mask layer and etching an opening . . . through an aperture in said patterned resist layer . . . using a combination of ammonia and at least one fluorocarbon . . . and wherein the flow rate ratio of said at least one fluorocarbon to said ammonia is from about 2:1 to about 40:1," as recited by claim 36, or "[a] method of forming a conductive plug . . . inside a self-aligned contact opening . . . with a plasma etchant mixture consisting essentially of ammonia and at least one fluorocarbon at a temperature within the range of about -50 to about 80 degrees Celsius so as to form a self-aligned contact opening . . . wherein the flow rate ratio of said at least one fluorocarbon to said ammonia is from about 2:1 to about 40:1, and depositing a conductive plug inside said etched opening," as recited by claim 64.

Applicant respectfully disagrees with the Office Action's further assertion "[w]ith respect to claims 4-7, 15-17, 20-25, 39-41, 44-45, 64-70, claimed ranges of temperature, flow rates, flow rate ratios in the etching steps are considered to involve routine optimization." (Office Action, page 7).

Applicant's specification discloses that "a plasma etchant mixture containing ammonia and at least on fluorocarbon at a pedestal temperature within the range of about –50 to about 80 degrees Celsius [forms] . . . a self-aligned contact opening . . . [and] further forms a protective or passivating (nitrogen-containing) layer over opposed side wall

spacers." (Applicant's specification, page 5, lines 12-18). Further, the present invention eliminates the "etch stop" problems associated with the prior art processes by utilizing, for example, the claimed flow rate ratios as discussed previously (See Applicant's specification, pages 7-10).

Accordingly, for the reasons provided above, allowance of claims 1-25, 36-46, and 64-70 is respectfully solicited.

Claims 2, 4-7, 13-14, 15-25, 36-46, and 64-70 stand rejected under 35 U.S.C. § 103 as being obvious over Levinstein in view of Tan et al. (U.S. Patent No. 6,140,168) (hereinafter "Tan"). Reconsideration is respectfully requested.

At the outset, claims 2, 4-7, 13-14, and 15-25 depend from and include all of the limitations of independent claim 1 and are allowable for at least those reasons provided above. Specifically, Levinstein fails to teach forming an opening, much less a self-aligned contact opening by an "etching composition [where the] flow rate ratio . . . is from about 2:1 to about 40:1," as recited by claim 1 (emphasis added).

Tan adds nothing to rectify the deficiencies found in Levinstein. Tan discloses forming a "self-aligned contact by using different etching rates to two materials of the spacer and cap layer." (Col. 2, lines 23-26). Tan also teaches that an undoped dielectric layer 114 is ion implanted in forming the self-aligned contact opening (Col. 2, lines 49-54). The surrounding dielectric layer not etched to form the contact opening remains undoped. The undoped dielectric layer prevents further etching in further wet etching sequences. The presence of the undoped dielectric layer is an important feature of Tan's invention.

Whereas, Levinstein discloses a completely different structure and is directed to solving a different problem. The structure in Levinstein has first and second level metallization contacts and a method is disclosed to prevent shorting of these metallization contacts. Further still, Levinstein provides a phosphorous-rich oxide layer 14 and

phosphorous-poor oxide layer 15. Levinstein teaches forming apertures in the doped layers. Tan specifically teaches away from forming a contact opening in surrounding doped layers.

Accordingly, the cited references fail to suggest the methods defined by Applicant's claims 1, 36, and 64.

In addition, claims 2, 4-7, 13-14, and 15-25 depend from and include all of the limitations of independent claim 1 and are allowable for at least those reasons provided above. Similarly, claims 37-46 depend from and include all of the limitations of independent claim 36 and are allowable for at least those reasons provided above. Claims 65-70 depend from and include all of the limitations of independent claim 64 and are allowable for at least those reasons provided above.

Claims 1-25, 36-46, and 64-70 stand rejected under 35 U.S.C. § 103 as being unpatentable over Tan in view of Ding et al. (U.S. Patent No. 5,814,563) (hereinafter "Ding") and Levinstein. Reconsideration is respectfully requested.

For at least the reasons provided above, there is no motivation to combine Tan with Levinstein. Specifically, Tan teaches formation of contact openings in an undoped layer, whereas, Levinstein teaches forming openings in two different doped layers.

Ding adds nothing to rectify the deficiencies found in Tan. Ding teaches an etching composition comprising a fluorohydrocarbon gas, an NH_3-generating gas, and a carbon-oxygen gas (Col. 5, lines 46-55).

Applicant respectfully submits that Ding does not teach "using ammonia in addition to fluorocarbon for plasma etching the insulative layer at a temperature of about –50 to 80°C with a high etch rate and an improved etch selectivity" as the Office Action asserts (Office Action, page 11) (emphasis added). Ding discloses using fluorohydrocarbons which contain hydrogen, not fluorocarbons as the Office Action asserts (Col. 5, lines 65-67).

In addition, there is no motivation to combine Tan with Ding. Ding utilizes a three-composition gas mixture to etch a dielectric layer that is entirely doped. Tan's layer 114b is not doped and "has better ability to prevent loss due to the wet etching." (Col. 3, lines 56-59). As discussed previously, this is an important feature of Tan's invention.

Accordingly, even if the references were combined as asserted in the Office Action, the combination would fail to suggest the invention defined by any of claims 1, 36, and 64. Claims 2-25 depend from and include all of the limitations of claim 1 and are similarly allowable. Claims 37-46 depend from and include all of the limitations of claim 36 and are similarly allowable. Claims 65-70 depend from and include all of the limitations of claim 64 and are similarly allowable.

In view of the above, each of the presently pending claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to withdraw the outstanding rejection of the claims and to pass this application to issue.

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Respectfully submitted,

By____________________

Thomas J. D'Amico
Registration No.: 28,371
DICKSTEIN SHAPIRO MORIN & OSHINSKY LLP
2101 L Street NW
Washington, DC 20037-1526
(202) 785-9700
Attorneys for Applicant

APPENDIX A

1. (twice amended) A method of forming an opening in an insulative layer formed over a substrate in a semiconductor device, comprising:

etching said insulative layer with an etching composition consisting essentially of ammonia and at least one fluorocarbon so as to form said opening, wherein the flow rate ratio of said at least one fluorocarbon to said ammonia is from about 2:1 to about 40:1.

13. (amended) The method of claim 12, [wherein said method does not remove side wall spacers which are formed along the sides of a gate stack and which align said contact opening to said substrate] further comprising forming sidewall spacers along the sides of gate stack structures, wherein said etching is performed such that the sidewall spacers of said gate stack structures are not etched, wherein said sidewall spacers define at least in part said opening formed in said insulative layer.

14. (amended) The method of claim 1, [wherein said method does not remove side wall spacers which are formed along the sides of a gate stack and which align said contact opening to said substrate] further comprising forming sidewall spacers along the sides of gate stack structures, wherein said etching is performed such that the sidewall spacers of said gate stack structures are not etched, wherein said sidewall spacers define at least in part said opening formed in said insulative layer.

36. (twice amended) A process for forming an opening in an insulative layer formed over a substrate in a semiconductor device, comprising:

forming a pair of adjacent gate stacks in said insulative layer;

forming [side wall] sidewall spacers on [side walls] sidewalls of said adjacent gate stacks;

forming a patterned photoresist mask layer over said insulative layer; and

etching an opening in said insulative layer through an aperture in said patterned resist layer, wherein said opening is etched through to said substrate using a combination of ammonia and at least one fluorocarbon, wherein said fluorocarbon is selected from the group consisting of C_4F_8, C_4F_6, C_5F_8, CF_4, C_2F_6, and C_3F_8; and wherein the flow rate ratio of said at least one fluorocarbon to said ammonia is from about 2:1 to about 40:1.

43. (twice amended) The process of claim 42, wherein said [contact] opening is formed between said [side wall] sidewall spacers on said pair of adjacent gate stacks.

64. (twice amended) A method of forming a conductive plug inside a self-aligned contact opening [in an insulative layer] formed between adjacent gate stacks with sidewall spacers in an insulative layer formed over a substrate in a semiconductor device, comprising:

contacting said insulative layer with a plasma etchant mixture consisting essentially of ammonia and at least one fluorocarbon at a temperature within the range of from about -50 to about 80 degrees Celsius so as to form a self-aligned contact opening defined at least in part by said sidewall spacers on adjacent gate stacks in said insulative layer without an etch stop, wherein said contacting further forms a protective layer over opposed [side wall] sidewall spacers which have been formed over said gate stacks, wherein the flow rate ratio of said at least one fluorocarbon to said ammonia is from about 2:1 to about 40:1; and,

depositing a conductive plug inside said etched opening such that said conductive plug is separated from said [side wall] sidewall spacers by said protective layer.